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Water balance evaluation using two types of lysimeters

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Summary

The lysimeter station in Ljubljana Klece, Slovenia, was built at the beginning of the nineties. One large (1.8 m diameter and 2 m depth) non-weighable lysimeter with artificially filled soil determines seepage water. The main technical facilities contain concrete lysimeter vessels, a sampling shaft and tipping buckets. Water balance is determined by means of evapotranspiration calculated after Penman-Monteith method based on meteorological data and daily outflow measurements. In 2010 new and technically advanced weighing lysimeter was installed in Kleče that enables state of the art measurements of the water balance parameters. Despite the technology advancement, correct data interpretation, evaluation as well as data quality control remain as the challenges of lysimetry. Therefore, beside reconstructive measures, improvements regarding data management, data interpretation and quality control must be made.

Keywords: water cycle, natural nitrate background

Introduction

Lysimeters are a useful and reliable tool for the research of the water balance parameters, assessment of the climate change effects on the water cycle as well as evaluation of groundwater pollution prevention measurements. Lysimetry is fundamental for complex systems studies, i.e. the interaction of atmosphere – plant – soil – unsaturated zone and groundwater system.

Water plant Kleče is, with its total capacity of 2000 l/s, the heart of Ljubljana's fresh water supply system. The area of the water plant's watershed is used for agriculture, predominantly for intensive vegetable production. In the nineties nitrate (NO_3^-) concentration levels of the groundwater aquifer for city's water supply system were increasing, hence groundwater monitoring, monitoring of the nutrient content in the soils of the water protected areas and measurements of nitrate leaching through the soil profile on the area of Kleče water plant were set up. Established measurements and monitoring of NO_3-N in the soil, percolated water and groundwater enable quality monitoring of the soil and groundwater and provide control over agricultural practices, which influence the fresh water source. The results help to determine the correct use of plant fertilizers as well as enable prompt reaction to negative trends of the groundwater quality. Since the beginning of soil sampling monitoring in 2001, the situation has improved. The percentage of the land with acceptable NO_3-N levels increased and the percentage of the land with exceeded NO_3-N content decreased. Since the year 2002 concentration of NO_3-N in percolating water is monitored on the area of Kleče water plant (ZUPANC et al. 2005a, 2005b, BRAČIČ-ŽELEZNIK et al. 2007). On the premises no additional fertilizers are used, therefore the research was expanded to study nitrate natural background, such as mineralization form the soil and wet deposits. From the lysimeter 1.25 kg/ha N-NO_3 have been leached in 2003, 1.9 kg/ha in 2004, 7.9 kg/ha in 2005 and 13.6 kg/ha in 2006 (BRAČIČ-ŽELEZNIK et al. 2007). Objective of this paper is the comparison of data for the two different lysimeter types.

Material and Methods

The lysimeter station in Ljubljana Kleče, Slovenia, was built at the beginning of the nineties. One large (1.8 m diameter and 2 m depth) non-weighable lysimeter with artificially filled soil determines seepage water. The main technical facilities contain concrete lysimeter vessels, a sampling shaft and tipping buckets. Water balance is determined by means of evapotranspiration calculated after Penman-Monteith method based on meteorological data and daily outflow measurements (ZUPANC et al. 2005a, 2005b, BRAČIČ-ŽELEZNIK et al. 2007). In 2010 new and technically advanced weighing lysimeter was installed in Kleče that

Table 1: **Measured parameters on the old and new lysimeter in Kleče, Ljubljana**

	Parameter	Units	Time step
Lysimeter 1990	Outflow	ml	Daily
	NO_3 concentration outflow water	mg/l	Weekly
Lysimeter 2010	Water tension – lysimeter (100, 150, 190 cm)	hPa	10 min
	Water tension – field (190 cm)	hPa	10 min
	Water content (50, 100, 150 cm)	Vol %	10 min
	Soil temperature – lysimeter (50, 100, 150, 190 cm)	° C	10 min
	Soil temperature – field (190 cm)	° C	10 min

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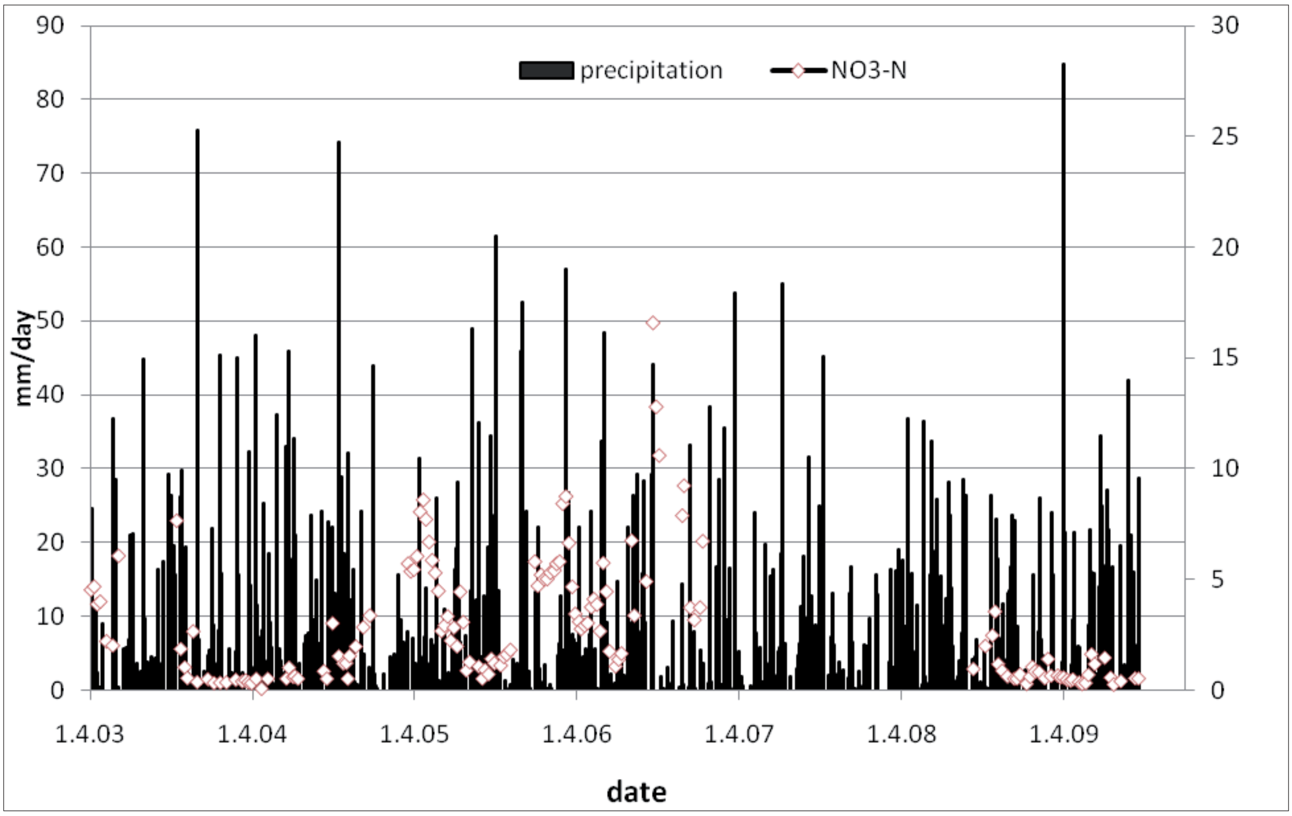

Figure 1: **Precipitation amount (mm/day) and nitrate concentration (mg/l) for the Water plant Kleče lysimeter constructed in 1990**

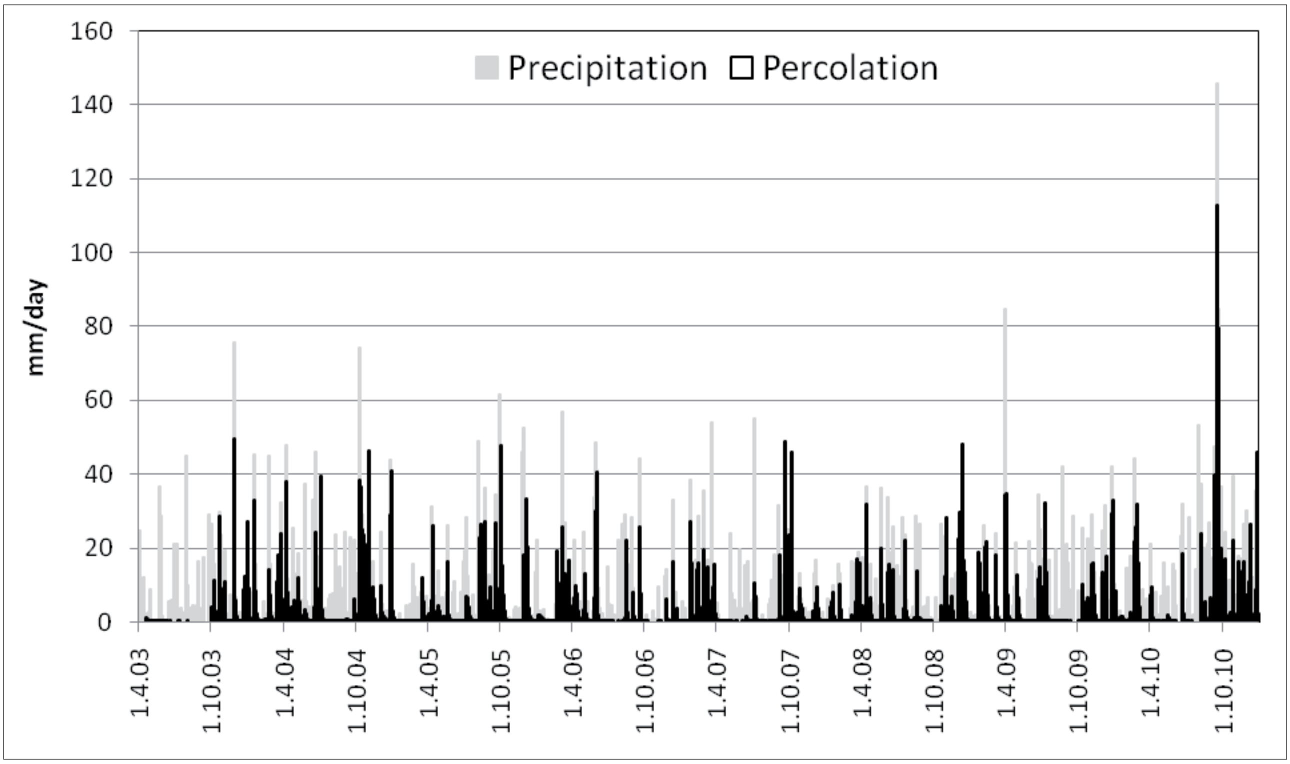

Figure 2: **Precipitation and percolation (mm/day) for the Water plant Kleče lysimeter constructed in 1990**

enables state of the art measurements of the water balance parameters. The monolith of 2 m height and 1 m diameter was cut from sandy gravel sediments on the area of the water pumping station. Inside the monolith tensiometers, TDR probes and suction cups were installed (*Table 1*).

Results and discussion

The old lysimeter provides historical data on outflow quantity (2003 – 2009) and quality (nitrate concentration measurements from 1st of April 2003 to 1st of April 2007; on-going since 1st of January 2009) (*Figures 1* and *2*). This facilitates estimation of how much nitrate is leached from non-fertilised area, thus giving the idea of natural background. However, given that environment inside the lysimeter vessel has been isolated for over two decades, it is a safe assumption even without additional research that the conditions in the lysimeter soil profile are different from those in the neighbouring soil. This has been also evident in changed vegetation. Field inspection showed that lysimeter's plant cover does not correspond with the Penman-MOnteith requirements for the reference surface, which should closely resemble an extensive surface of green grass of uniform height, actively growing, completely shading the ground and with adequate water. Due to the non-existent fertilisation, natural selection took place and weed species indicative for dry, acidic conditions prevailed. The detailed measurements inside and next to the new lysimeter of soil water status and temperature give much needed information about the conditions for microorganisms and for potential for chemical changes in the soil (*Table 1*).

Conclusions

Despite the technology advancement, correct data interpretation, evaluation as well as data quality control remain as the challenges of lysimetry. Therefore, beside reconstructive measures, improvements regarding data management, data interpretation and quality control must be made.

Literature

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